Numerical method for 1d fdtd simulation in plasma

1.Solve Maxwell equation in frequency domain

2.Solve Maxwell equation in time domain

Basic function:

Using dimensionless equations by normalizing with characteristic parameters:

To extra the dimensionless time evolution equations, Let’s rearrange the normalized parameters to one side :

The constrain condition of these dimensionless parameters are

From the equations above, we have

Consider than .also Let E0=1, than we have

Finally, we have

Consider only one dimension along z axis, we have

Node and space distribution of E and H

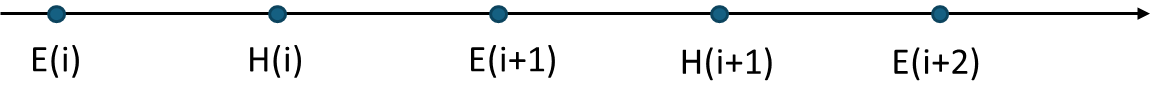
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Figure 1 node i and space position of E and H

Reorganized the formula, we get

Where

Similarly ,as for Ex ,Ez, Hx and Hy, we have

For Ex

For Ez

For Hx

For Hy

Beside this ,we also need to solve the evolution of J. First of all, let’s discrete the J equation

Consider J(i) at the same space position of E(i), then we have

Replace the and simplify the equation, we have

Where

Convolution Perfect March Layer Calculation

After dimensionless:

Appendix

Absorbing Boundary Conditions

1. Mur’s Boundary Conditions[1]

initial work : B. Engquist and A. Majda, “Absorbing boundary conditions for the numerical simulation of waves,” Mathematics of Computation, vol. 31, 1977, pp. 629-651.[2]

1. Convolution Perfect Match Layer

A screenshot of a math equation

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A screenshot of a computer

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A blue and white background with text

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A diagram of a mathematical equation

Description automatically generated with medium confidence

A math equations on a blue background

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A diagram of mathematical equations

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A screenshot of a math equation

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1. PML theory
2. CPML theory

[1] Dr. Mohamed Bakr, ‘EE757 Numerical Techniques in Electromagnetics Lecture 8’.

[2] B. Engquist and A. Majda, ‘Absorbing Boundary Conditions for the Numerical Simulation of Waves’, 1977.